Development and Demonstration of a Fuel-Efficient Class 8 Tractor & Trailer SuperTruck

Engine Systems (Project ID: ACS 103)

DOE Contract: DE-EE0007767

NETL Project Officer: Ralph Nine NETL Project Manager: Roland Gravel

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DOE MERIT REVIEW

June 6 - 9, 2017

Navistar & DOE SuperTruck II

Development and Demonstration

Together with our partners, we will deliver the following:

Greater than 100% improvement in vehicle freight efficiency (FE) (on a ton-mile-per-gallon basis) relative to a 2009 baseline with a stretch goal XXX% improvement.

Greater than or equal to 55% engine brake thermal efficiency (BTE) demonstrated in an operational engine at a 65-mph cruise point on a dynamometer.

Develop technologies that are commercially cost effective in terms of a simple payback.

Partnerships and Laboratories

Our partners:

Department of Energy

Argonne (ANL)

Gas Compression Ignition (GCI) and Combustion Systems

Lawrence Livermore (LLNL)

Aerodynamic CFD

Bosch

Fuel Systems

TPI

Composites

Dana

Axles and Drive Systems

Period Deliverables

Budget Period 1

Requirements / Technology Assessment & Initial Hardware Testing

Budget Period 2

Technology Development & Concept Readiness Demonstration

Budget Period 3

Technology Finalization & Validation

Budget Period 4

Tractor/Trailer Fabrication, Integration & Commissioning Demonstration

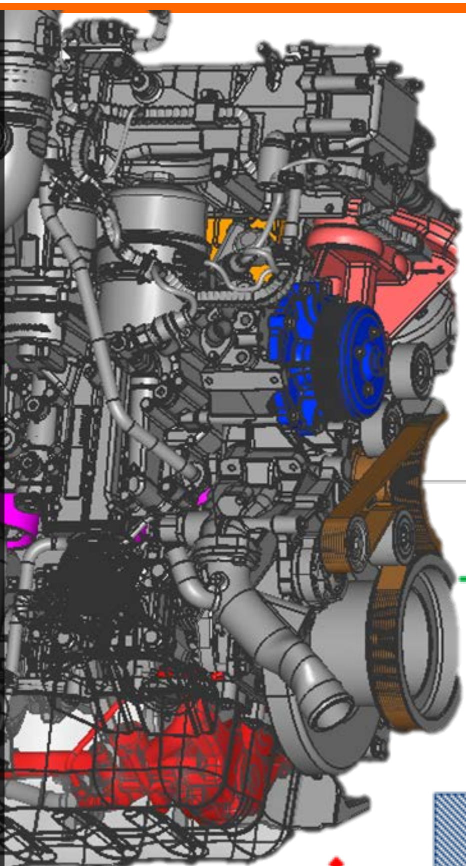
Budget Period 5

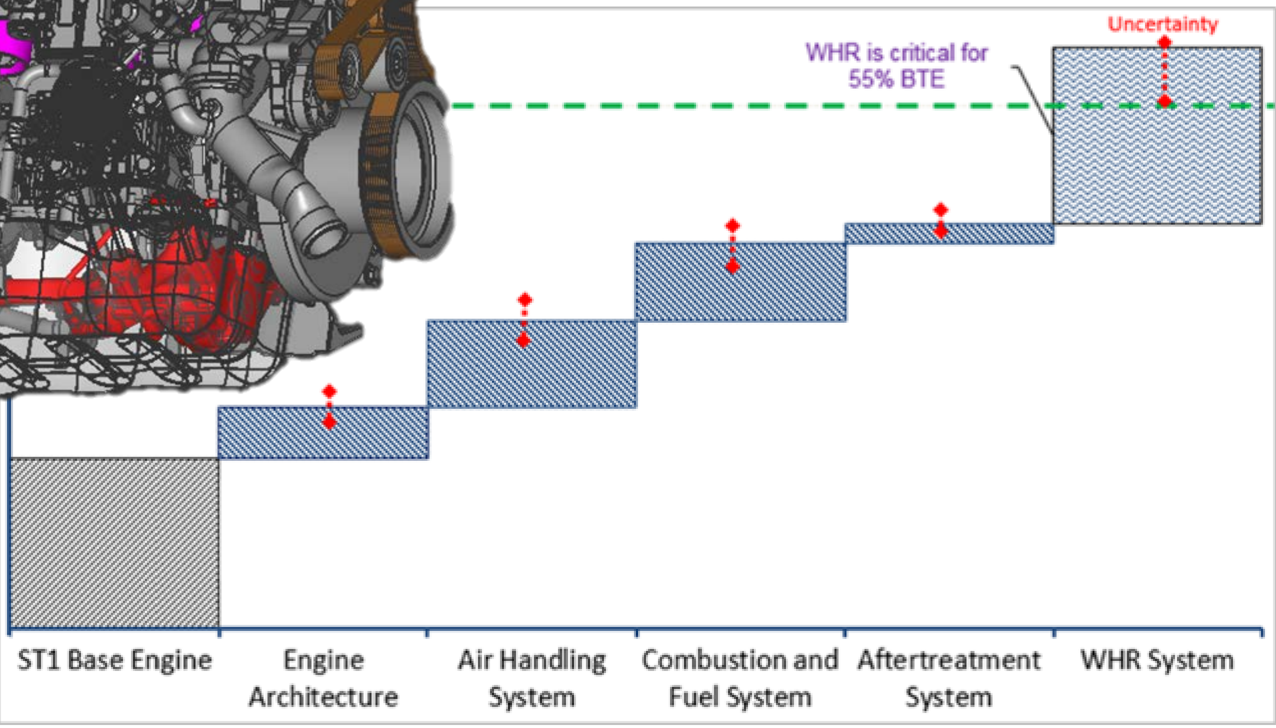
Fuel Economy & BTE; and Program Completion

Component- and system-level

- Engine Architecture
- Air Handing System
- Combustion & Fuel System
- Aftertreatment System
- WHR System

Includes (GCI) W/ Argonne (ANL)

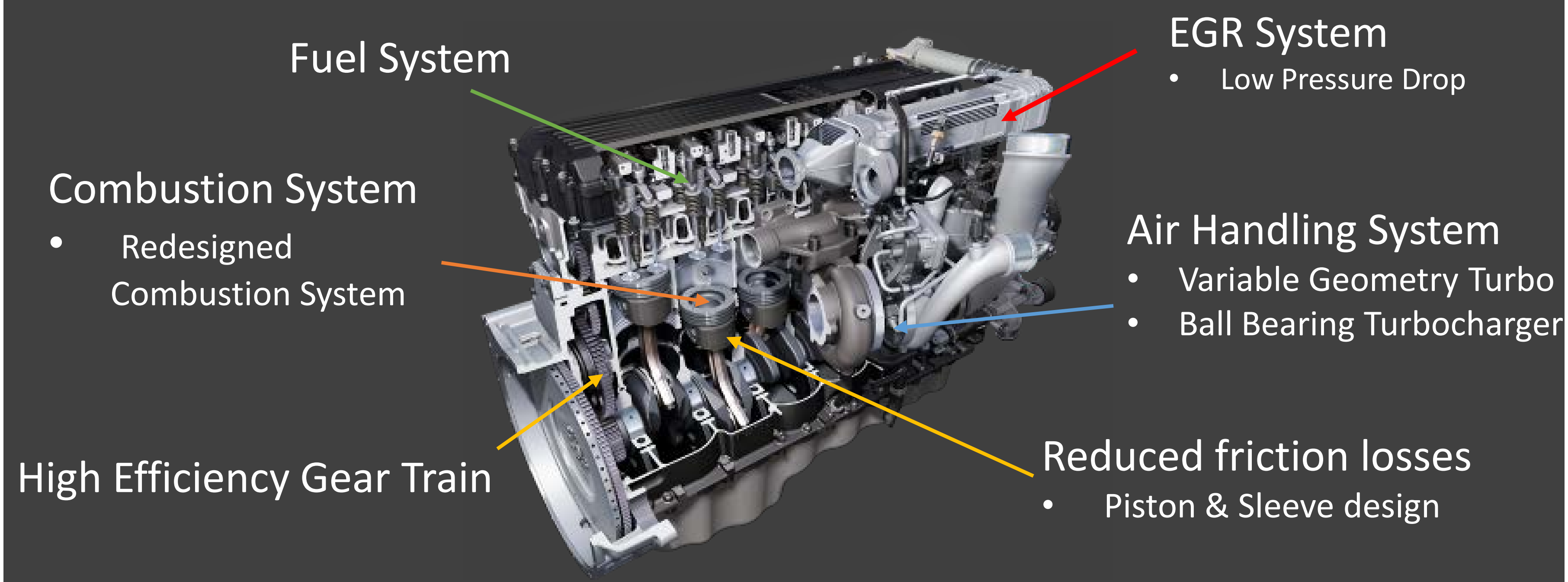




Engine 55% BTE Objective

- Objective: Research, develop, and demonstrate a heavy duty engine that achieves following goals:
  - Attain greater than or equal to 55% BTE demonstrated in an operational engine at a 65-mph cruise point on a dynamometer
  - Meets prevailing federal emission standards

Architecture



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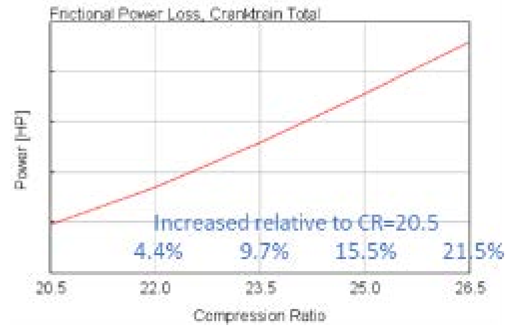
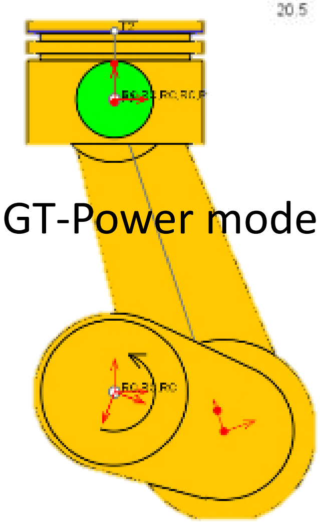
Detailed friction model developed
Investigating opportunities for increased friction reduction.



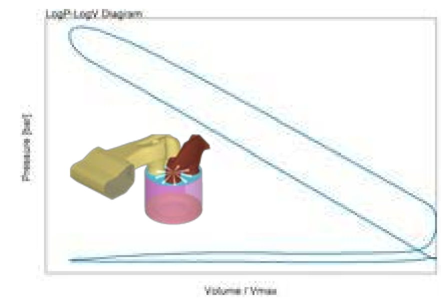
Friction power increases near a linearly rate with CR on cranktrain.

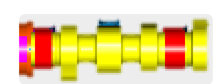
High PCP in combination with high CR gives diminishing returns.

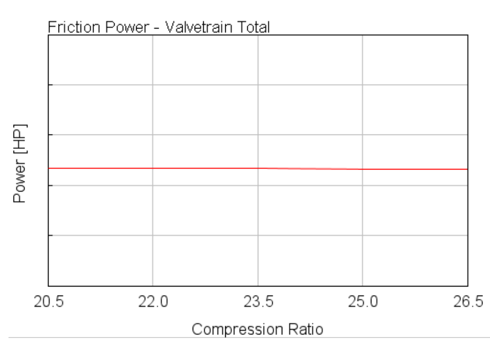
There is minimal effect on the valvetrain friction power from the increased CR.

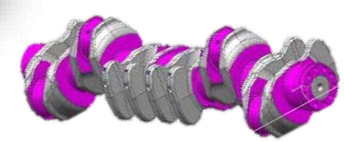


GT-Power model



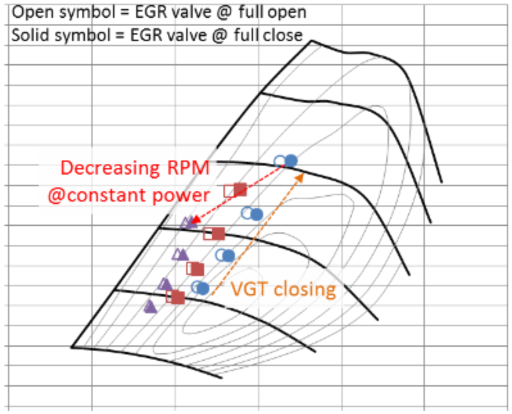




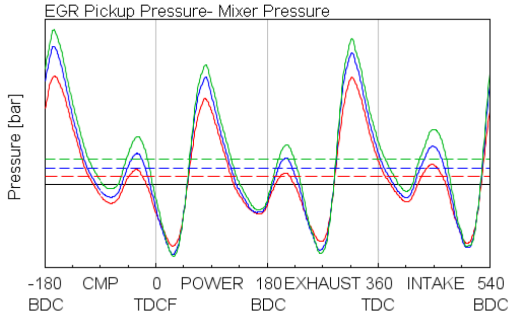


Turbocharger efficiency is a key area for engine BTE gain.
Exhaust and EGR system design modifications, including the low pressure EGR loop.

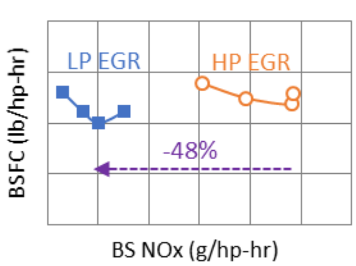
Results show that, at a constant power, reducing the engine speed results in a shift of compressor efficiency.

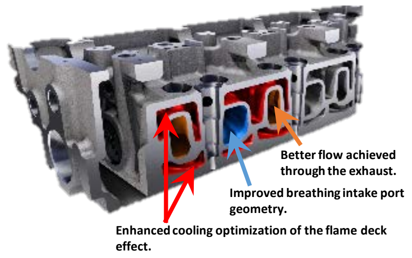


Proper pulse energy management could drive EGR even at negative back to boost pressure difference.



LP EGR could achieve significant NOx reduction with no negative impact to BSFC.

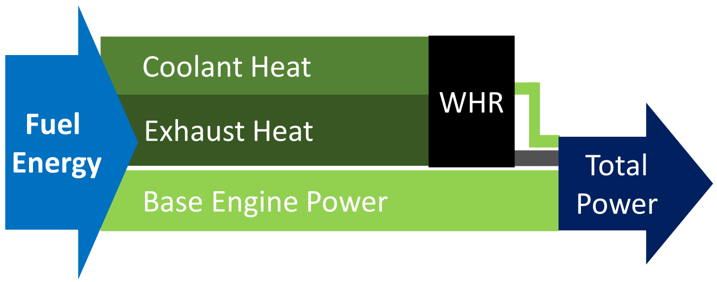


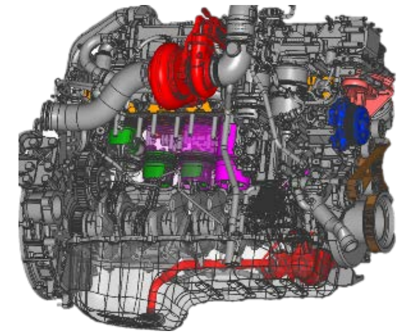


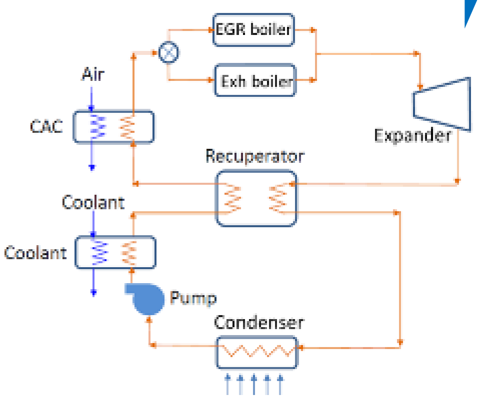
WHR ORC

WHR is critical in reaching 55% BTE. Major sources of waste heat include engine coolant, CAC, EGR, and exhaust.

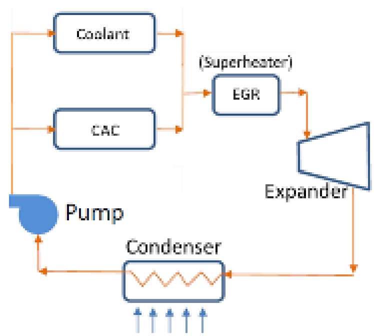
Models have been developed, optimizing system configurations to maximize the BTE gain.





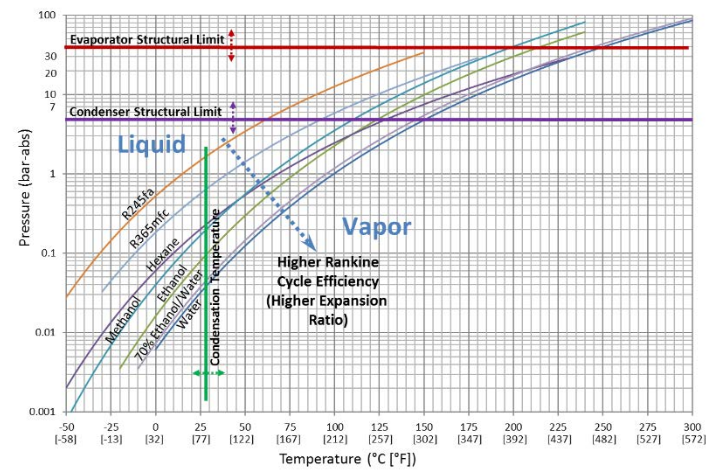


HT



LT

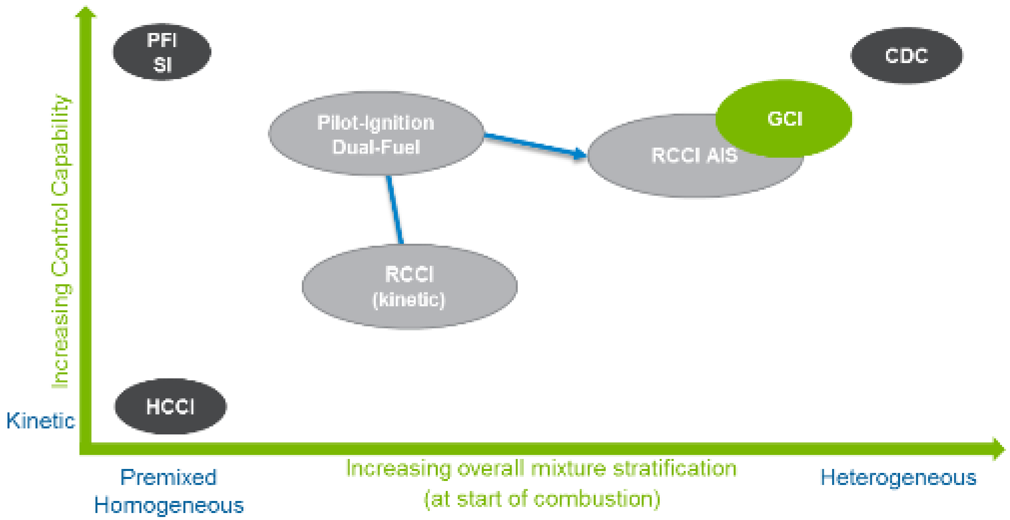
Split systems are being investigated: HT and LT loops.



Working fluid must be selected based on system.

(ANL) Gasoline Compression Ignition Evaluation

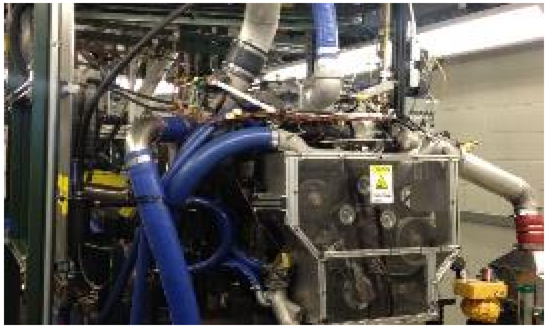
Objective: Evaluate performance opportunities with new gasoline (GCI) strategy



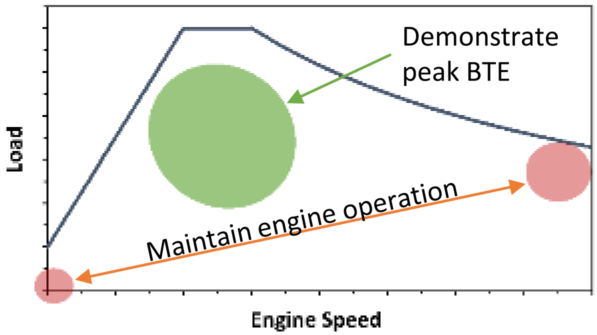
GCI concept for SuperTruck II operating targets

- Build off prior research into LTC and GCI
- Demonstrate increased BTE at key operating conditions
- Maintain overall engine operating range

Utilize engine platform with PFI and DI capabilities



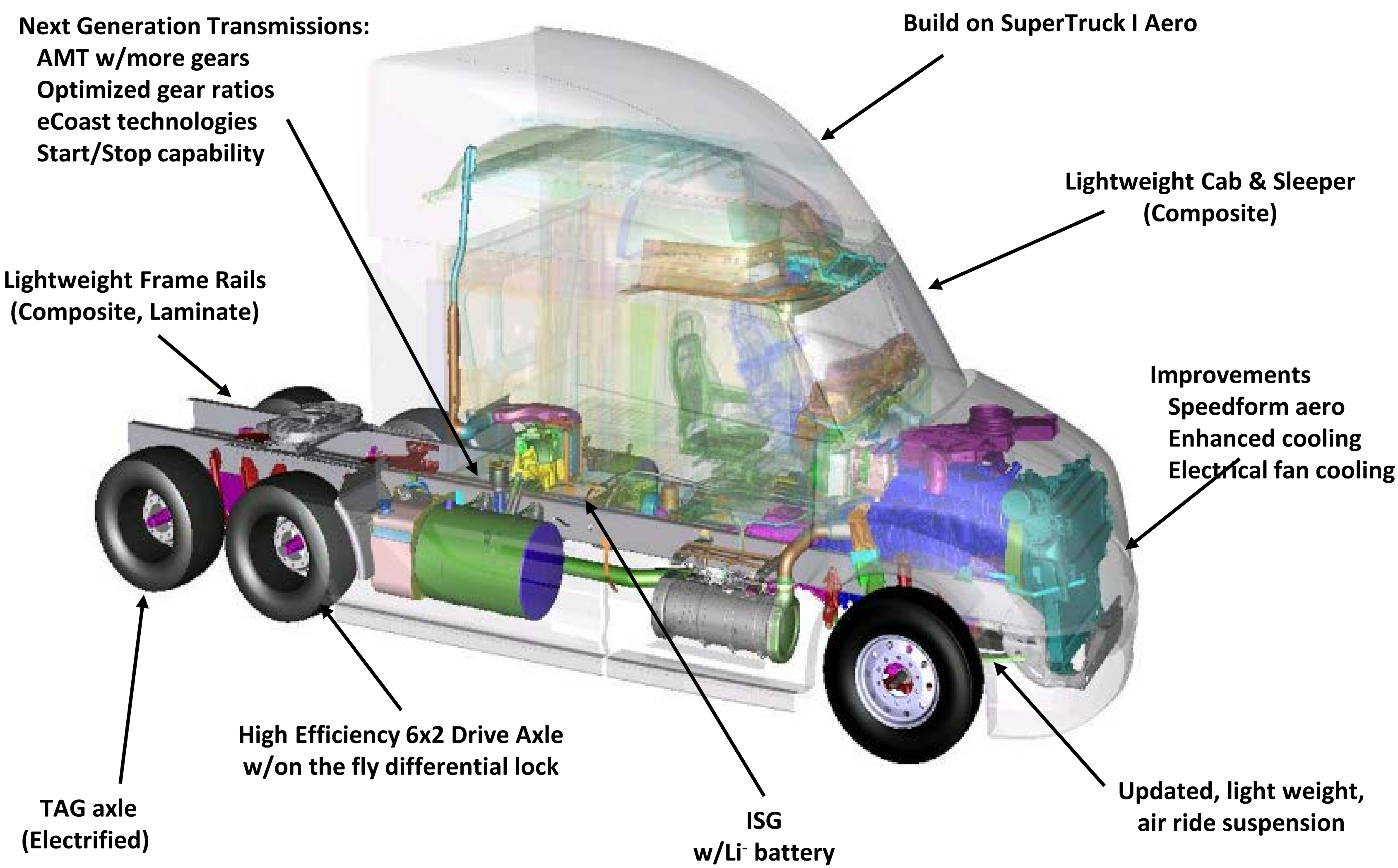
Initial investigations underway with 87 AKI E10 pump gasoline



Vehicle

Greater than 100% improvement in vehicle freight efficiency (FE) (on a ton-mile-per-gallon basis) relative to a 2009 baseline with a stretch goal XXX% improvement.

SuperTruck II: Design Philosophy



Drivetrain/Axles

Defining Scope of Work for Navistar ST-II DOE program:

Motorized Electric Tag Axle

Tag axle auxiliary electric motor(s) for improved traction of 6x2

Working with DANA and E-motor suppliers to select most viable configuration

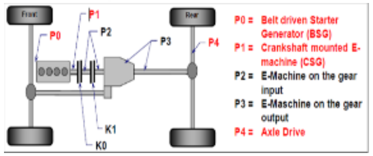
Simulation Analysis under way

Defined vehicle architecture parameters

Defined viable HW configuartions options

Defined E-Motor characterisics

Defined road cycles for simulation



Hybrid Module

Integrated on transmission for high power and efficient operation

Drive axles

RAR=X.XX prototype- gear set designed, CAE work complete.

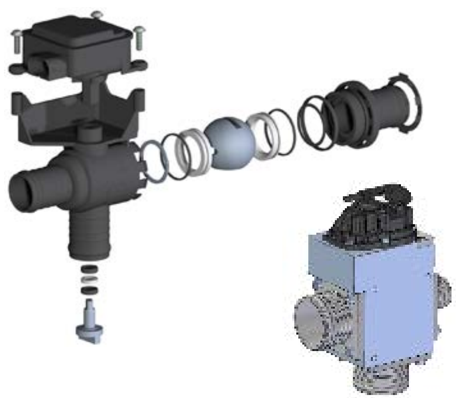
RAR <X.XX – feasibility study, results/conclusion byQ3 2017

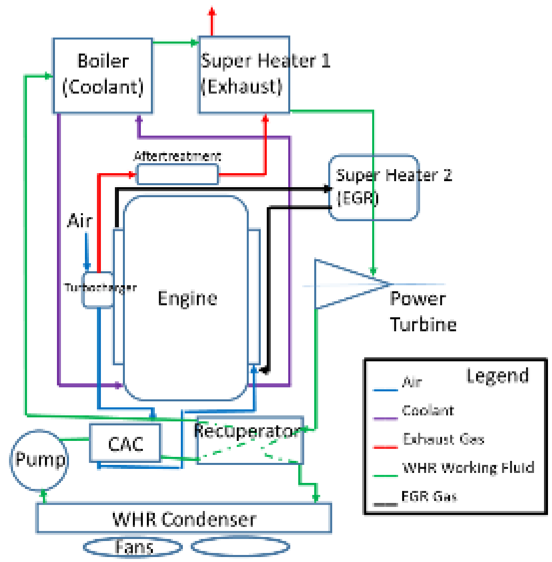
On-The-Fly Diff. Lock - started existing HW component durability analysis for cycle life testing, MRD- Q4-2017

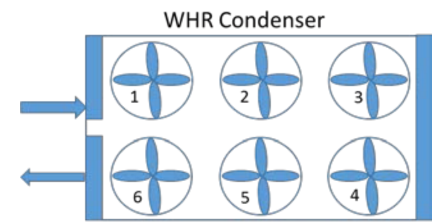
Advanced Cooling

Advanced Cooling Activities

- Designing cooling system configuration
  - Reviewing a common cooling/WHR approach
  - Defining an eFan approach to engine cooling
  - Defining electric accessories (fans, coolant pump, coolant control valves)







Fan-on Order: 1-2-3-4-5-6

Develop coolant diverter valve with IMI

This valve will replace the thermostats, can be used to optimize the flows to the cylinder head and the block.

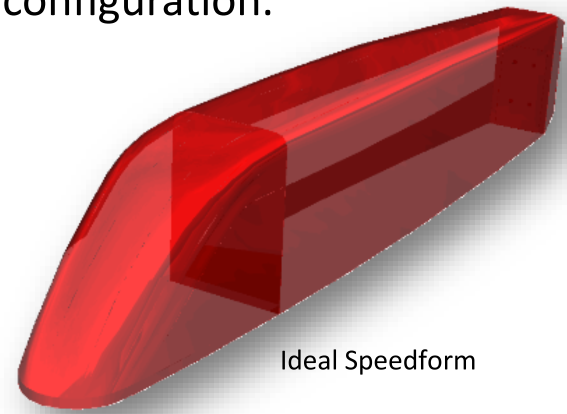
WHR condenser is the only heat exchanger in front of the truck

Using electric fans, electric coolant pump and electric control valves

Aerodynamic Development

Supertruck Architecture Relative to Peak Aero Performance Speedform GSF2:

Idealized Tractor Trailer Speedform (GSF2) Developed With LLNL represents the optimal drag configuration.



Ideal Speedform

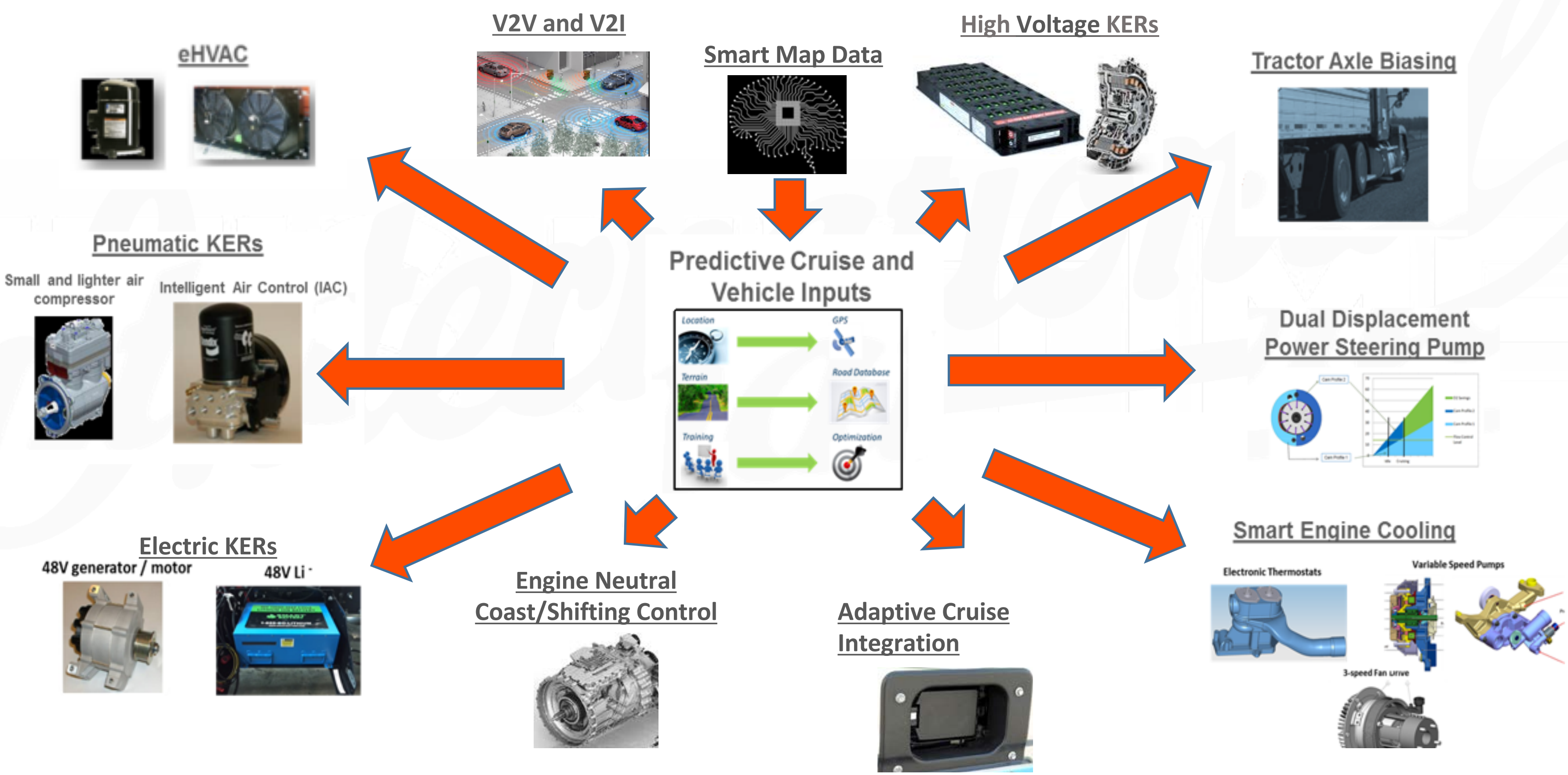
Relative to peak aero model- SuperTruck T4 Configuration (SuperTruck I) achieved 48% of the potential drag improvement.

Supertruck 1 Speedform

Further aero improvement opportunities are being evaluated to achieve the optimal Tractor and Trailer Architecture.

Predictive Cruse Control

The Future of: PCC



Reviewer Comments